

Terra and Aqua MODIS Instrument Status

Jack Xiong

Code 614.4, NASA Goddard Space Flight Center

Acknowledgements:

MODIS Support Teams (MCST and SDST)
Science Discipline Cal/Val Representatives

MODIS Science Team Meeting, Marriott ICC, Hyattsville, MD 20783 (May 18, 2011)

Terra MODIS: over 11 years of successful operation
Aqua MODIS: over 9 years of successful operation

Terra



Aqua



MODIS observations:
36 bands (VIS - LWIR)

An unprecedented
amount of data products
with significant
contributions to the
broad user and science
community

Recent Activities

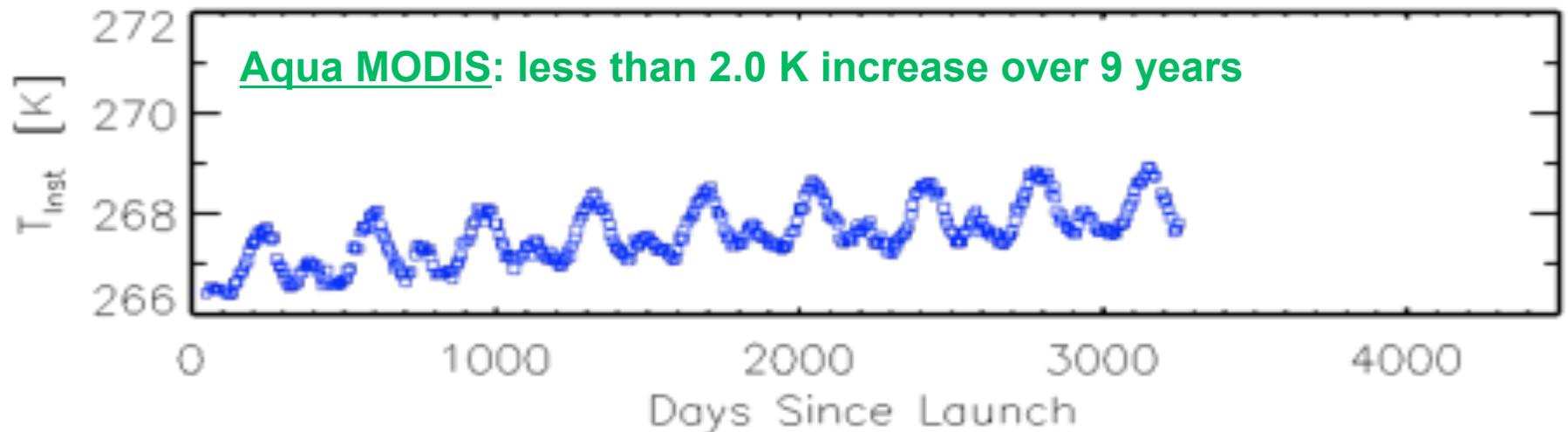
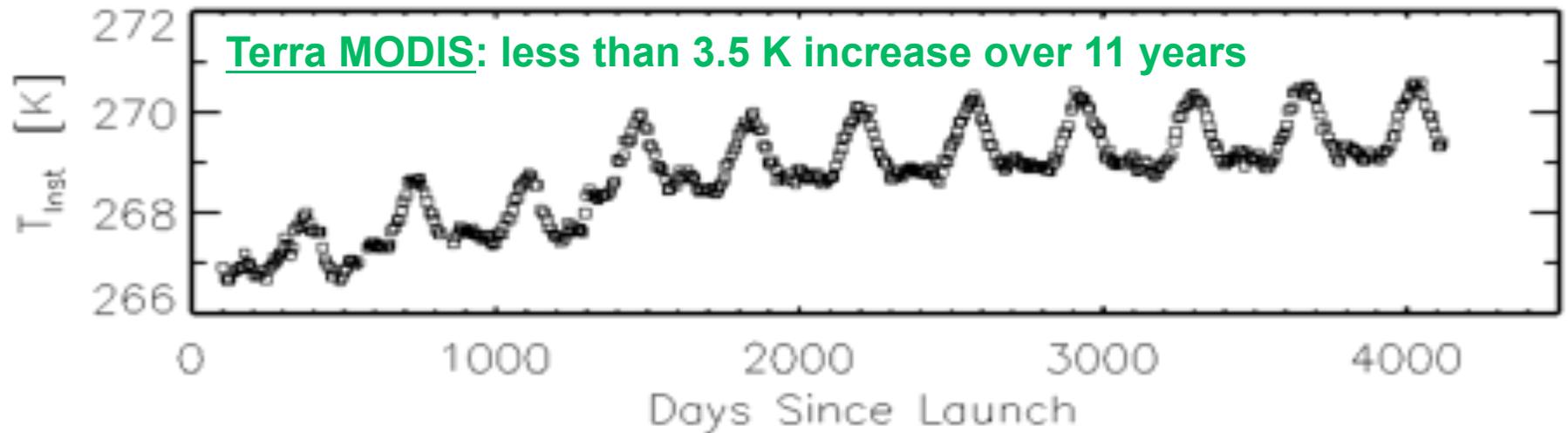
- **Senior Review for both Terra and Aqua Missions**
 - Terra effort led by M. Imhoff (Project Scientist)
 - Aqua effort led by C. Parkinson (Project Scientist)
 - MODIS contributions provided by M. King (Team Leader) with input from discipline and support team leads
- **MODIS Calibration Workshop (May 17, 2011)**
 - Presentations from members of MODIS calibration support team and science discipline representatives
 - Over 65 participants (69 last year for the MODIS/VIIRS calibration workshop)
 - **Continuous and additional calibration efforts are needed to address all the existing and newly identified issues**
 - All presentation materials will be posted on MODIS website

Instrument Operations

No New Changes to Instrument Operational Configurations

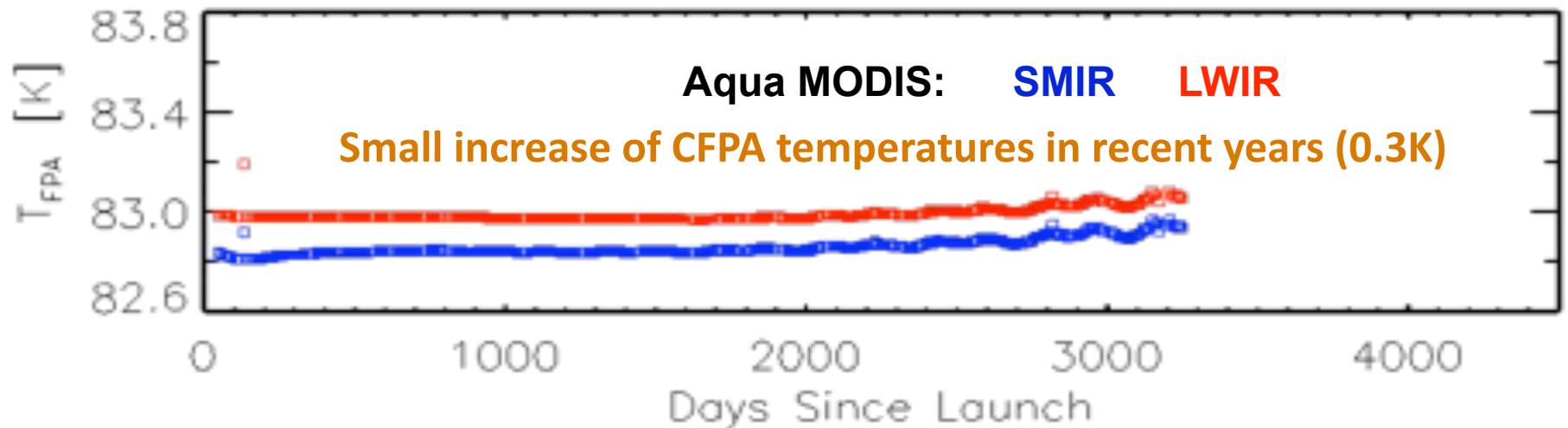
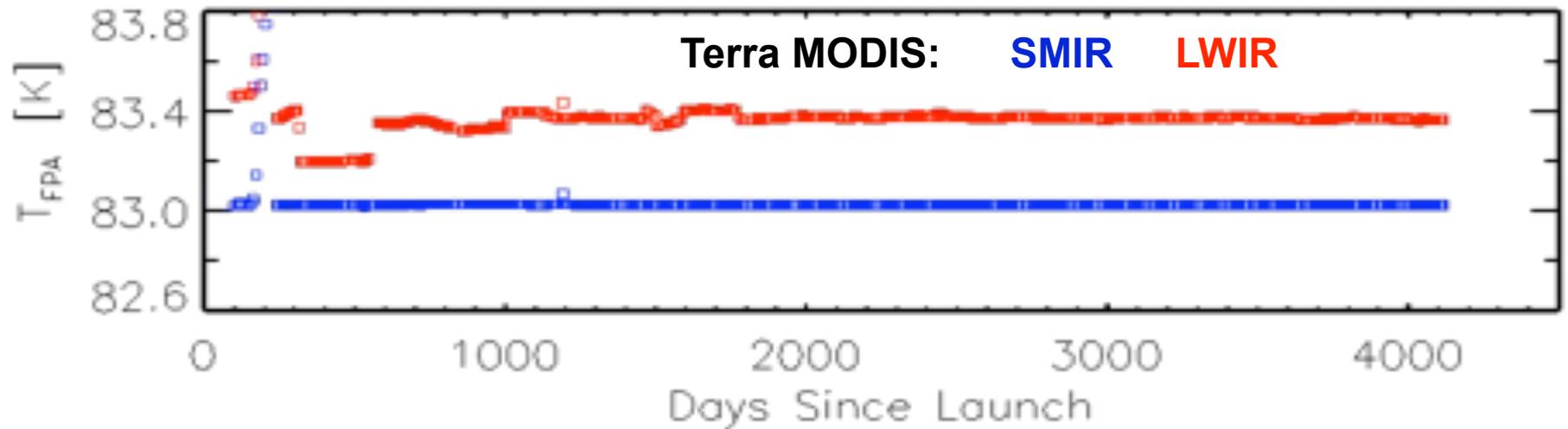
- Terra MODIS
 - A-side: launch to Oct 30, 2000
 - B-side: Oct 30, 2000 to June 15, 2001
 - A-side: July 02, 2001 to Sept 17, 2002
 - A-side electronics and B-side formatter: Sept 17, 2002 to present
 - BB temperatures set at 290K
 - Cold focal plane assemblies (FPA) controlled at 83K
- Aqua MODIS
 - Same B-side configuration since launch
 - BB temperatures set at 285K
 - Cold FPA controlled at 83K

Instrument Temperatures

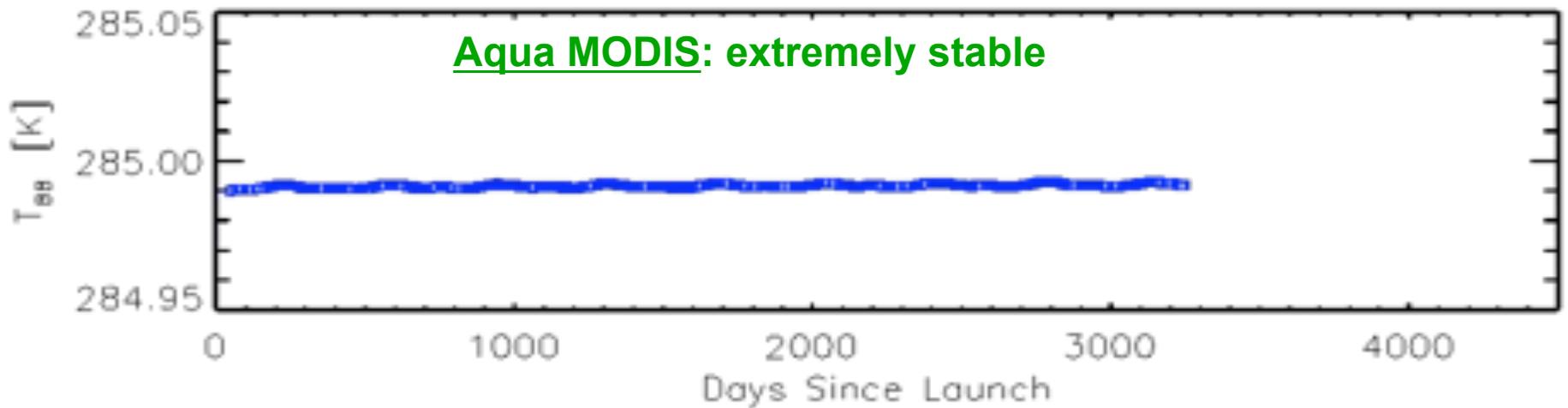
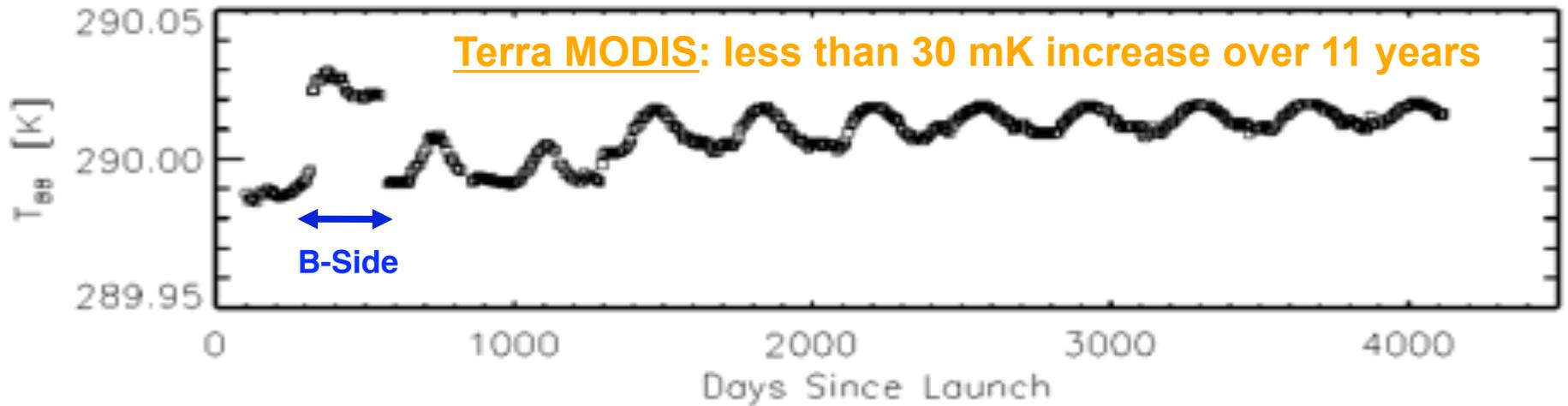


Similar trends for the VIS and NIR FPA temperatures

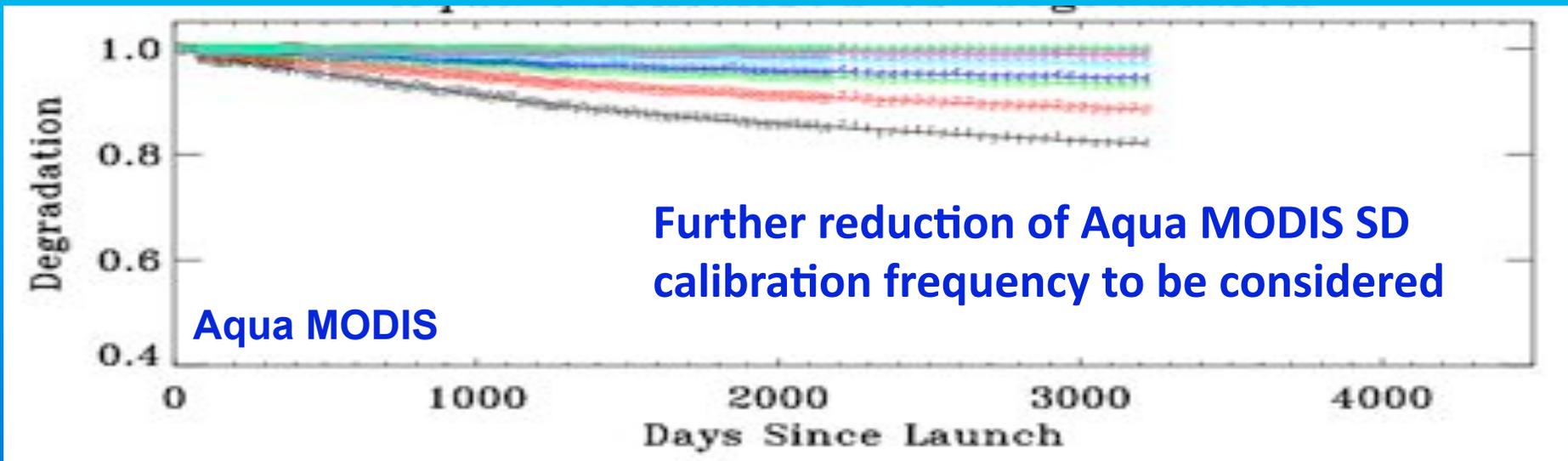
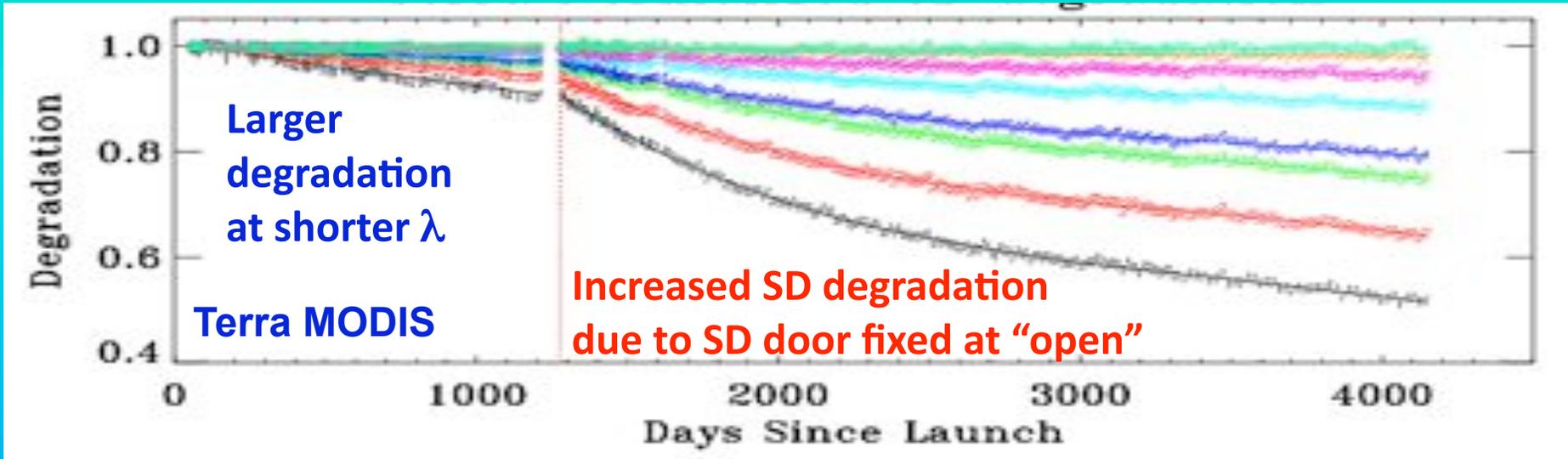
Cold Focal Plane Assembly (FPA) Temperatures



Blackbody Temperatures (nominal operation)



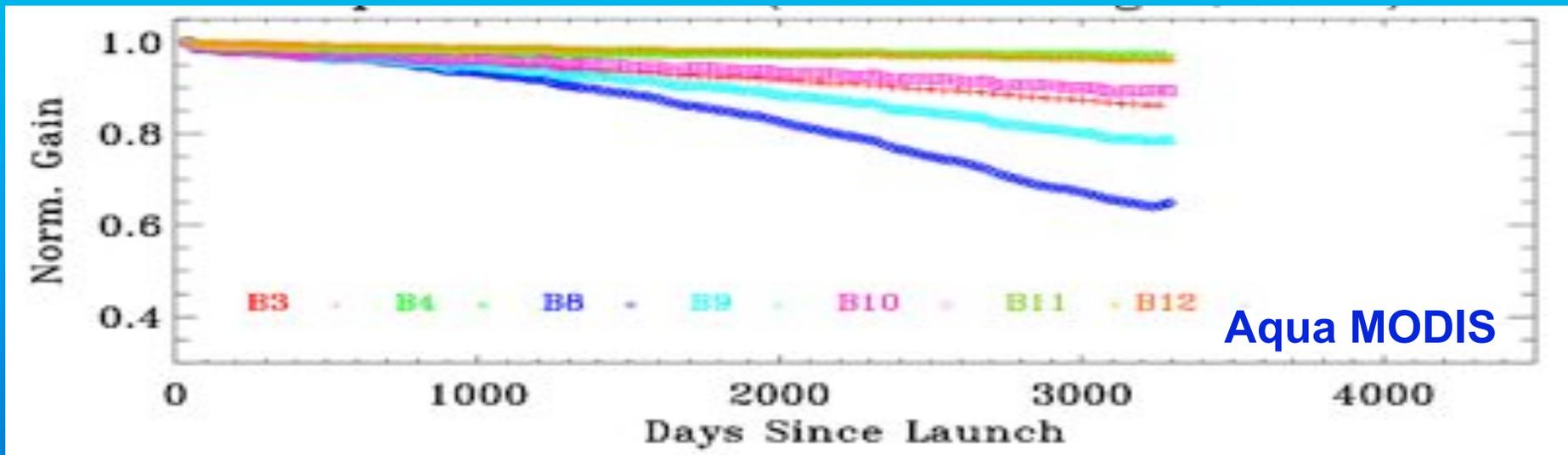
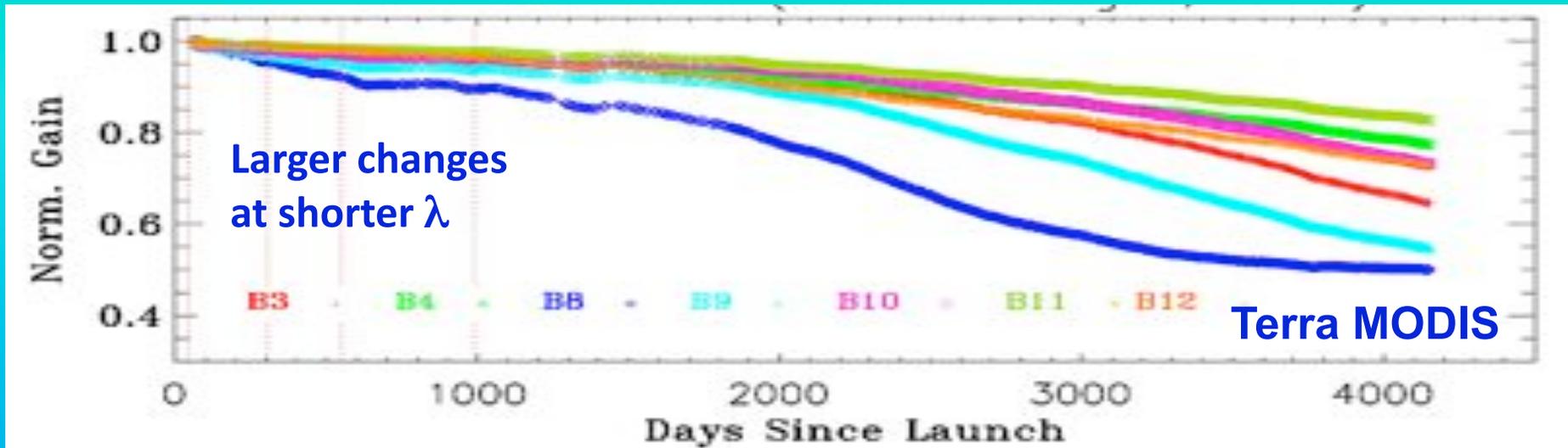
Solar Diffuser (SD) Degradation



On-board SD used for Reflective Solar Bands (RSB) calibration

RSB Spectral Band Responses (VIS)

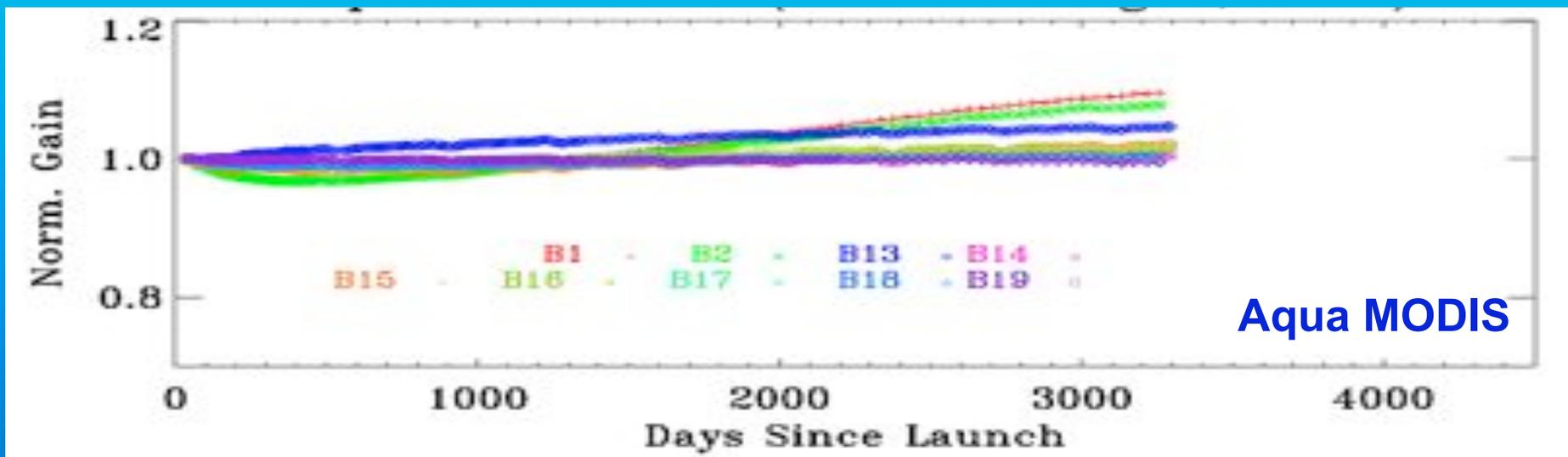
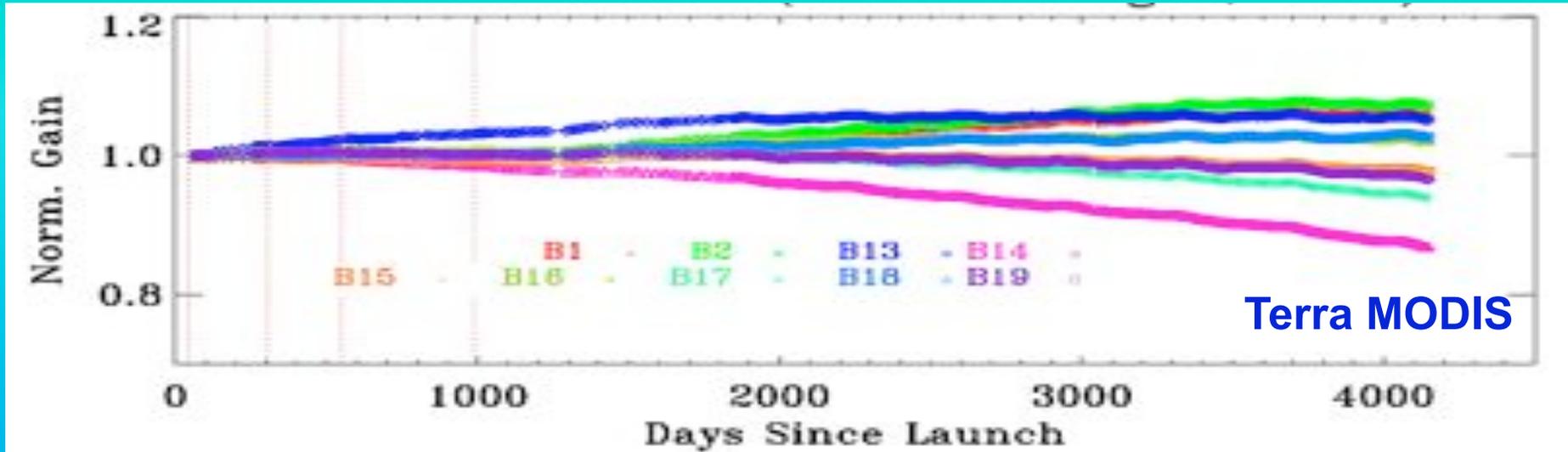
Band Averaged, Mirror Side 1



Terra/Aqua difference, wavelength, AOI and mirror side dependent

RSB Spectral Band Responses (NIR)

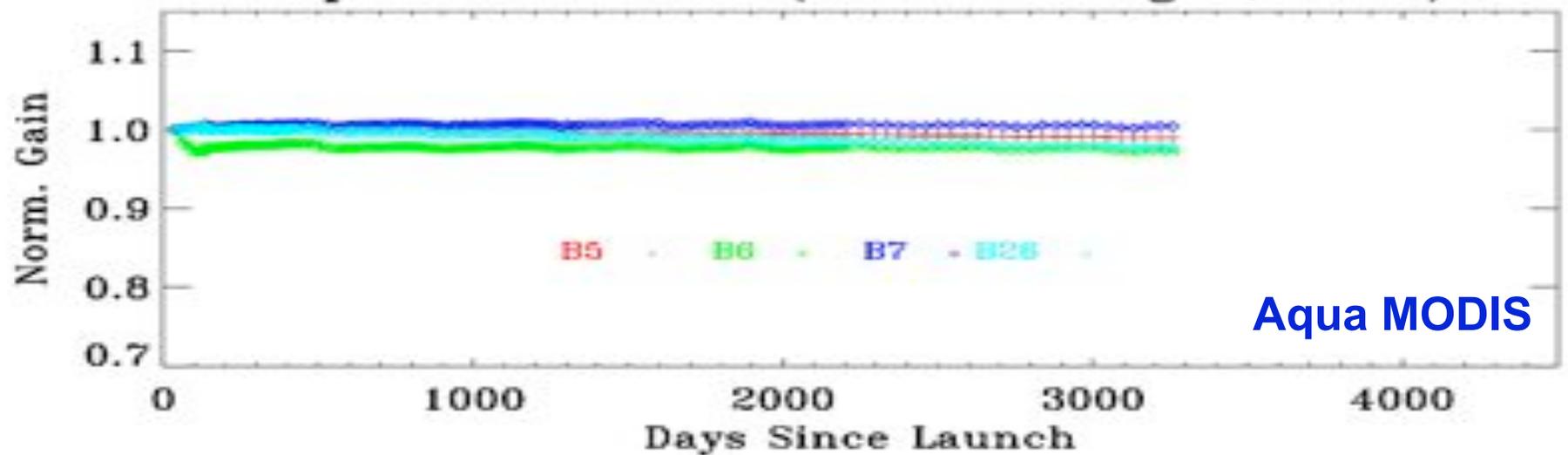
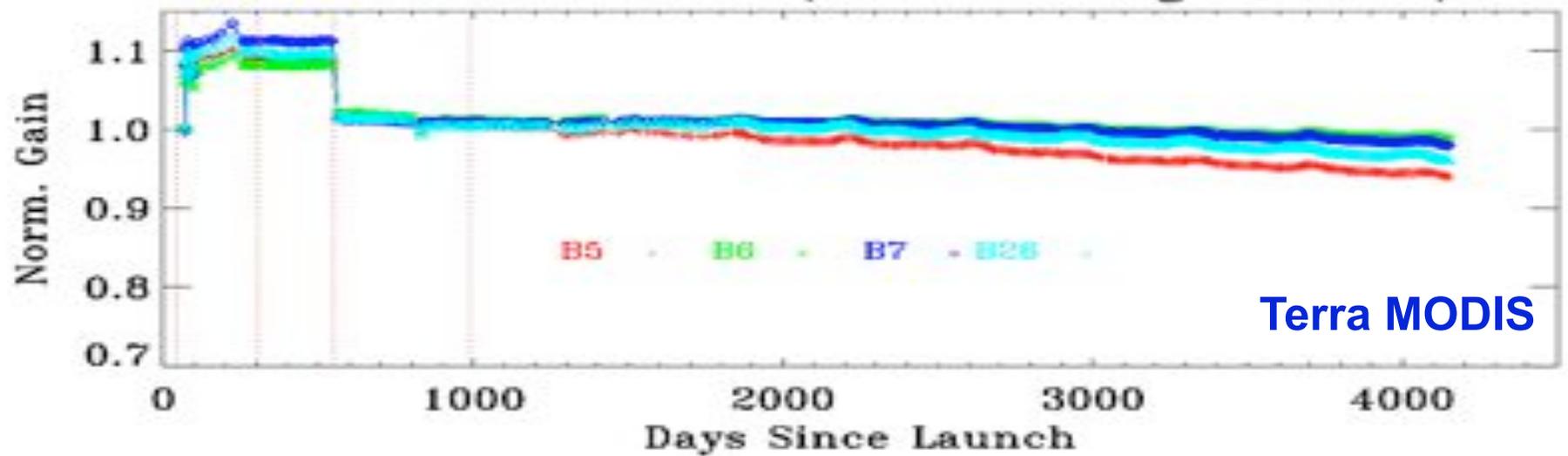
Band Averaged, Mirror Side 1



Some NIR bands show gain increase over time

RSB Spectral Band Responses (SWIR)

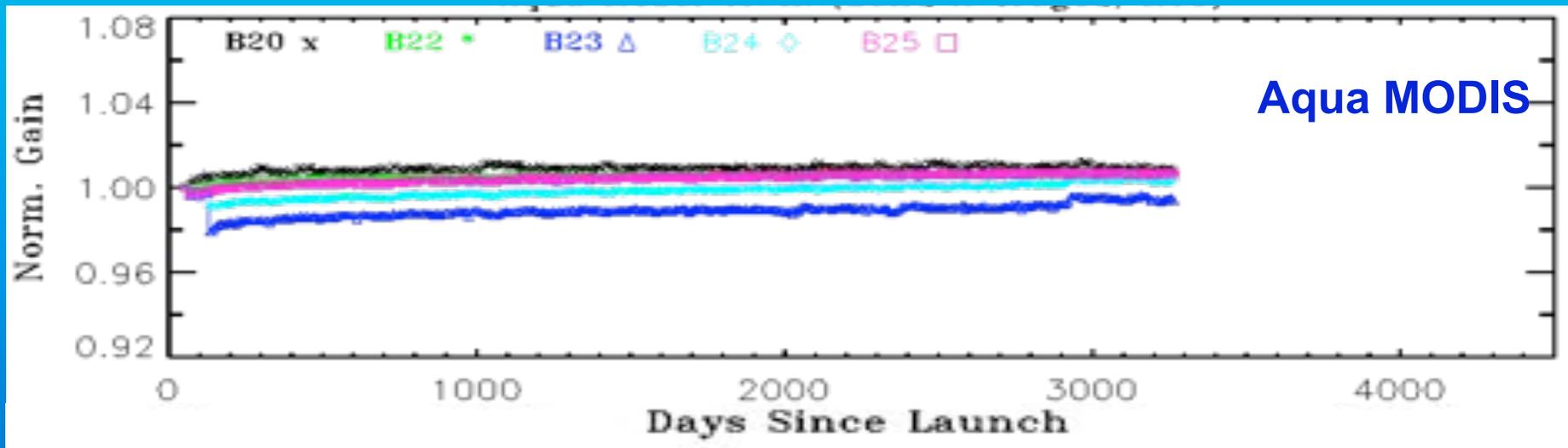
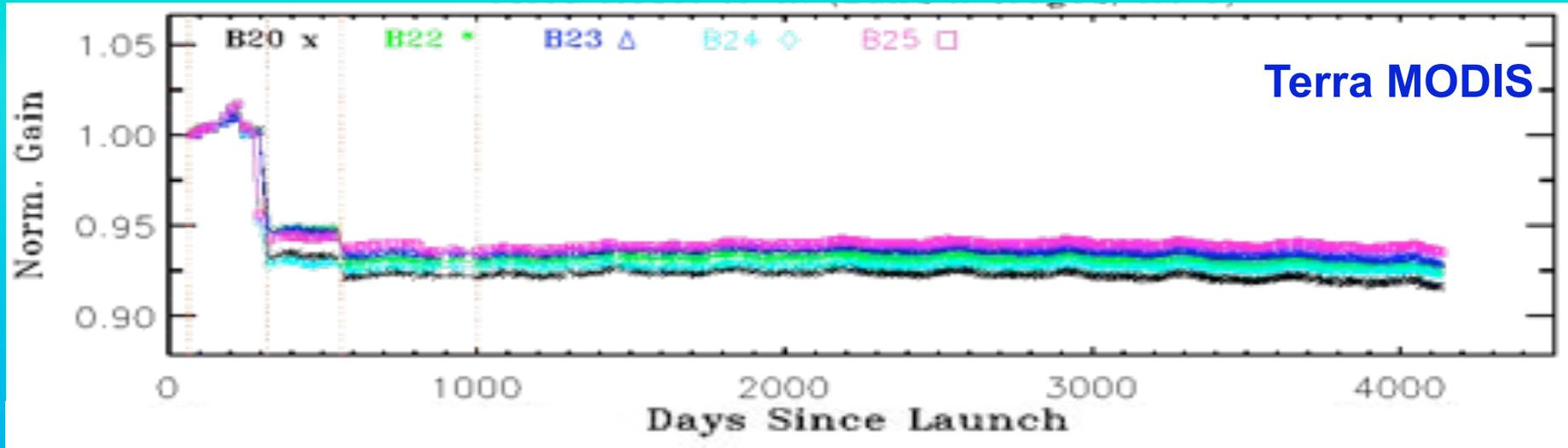
Band Averaged, Mirror Side 1



SWIR bands are located on the cold PFA controlled at 83 K

TEB Spectral Band Responses (MWIR)

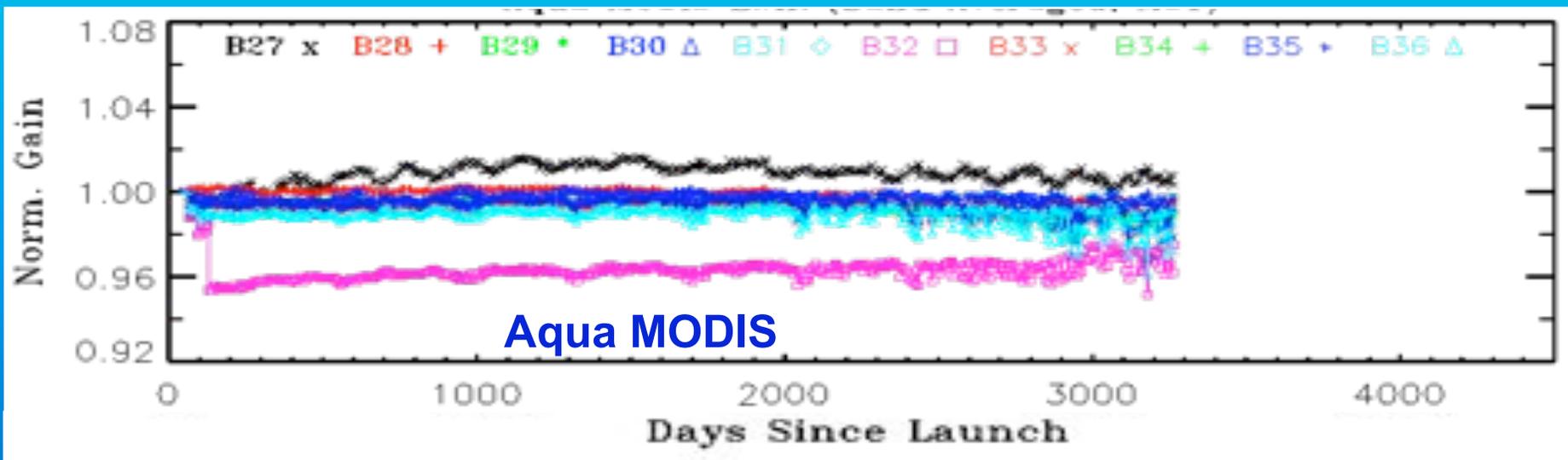
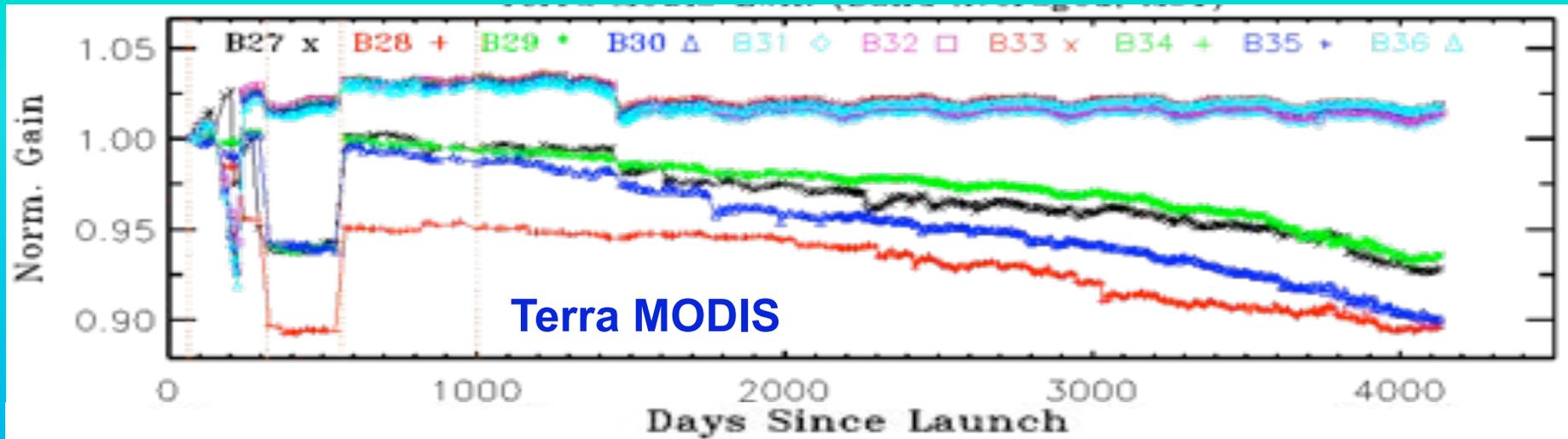
Band Averaged, Mirror Side 1



Changes in MWIR bands are small

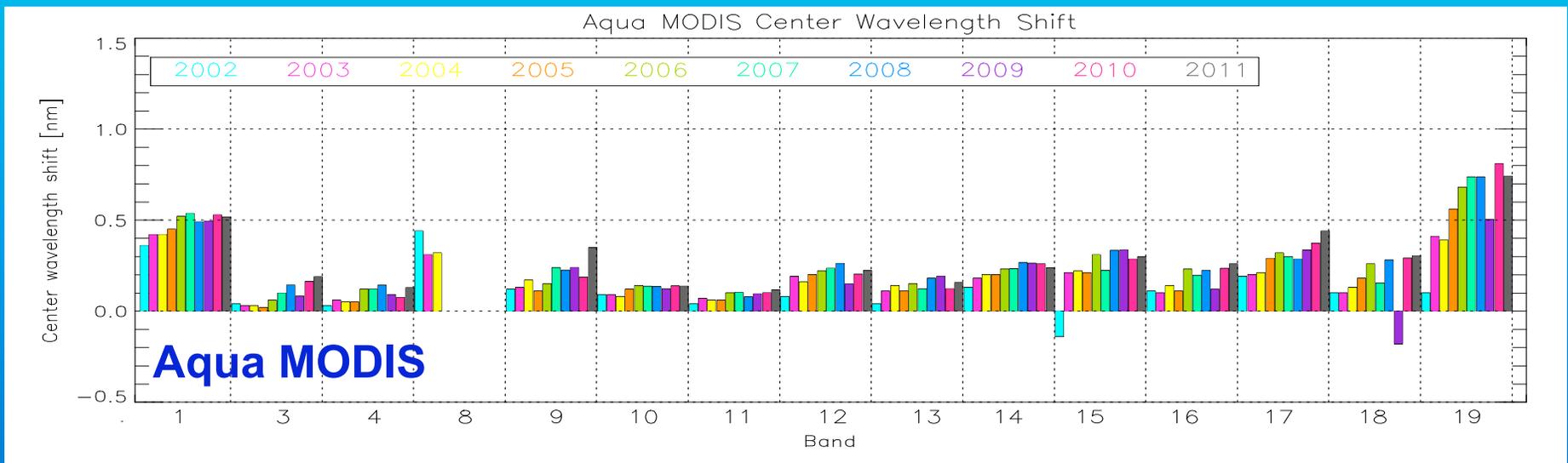
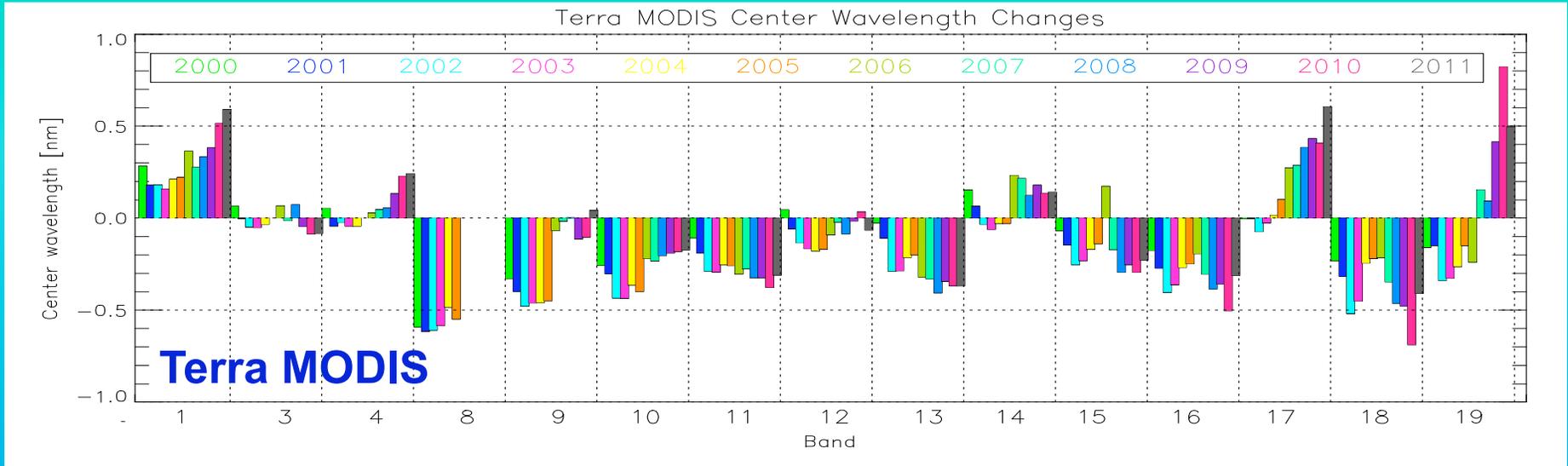
TEB Spectral Band Responses (LWIR)

Band Averaged, Mirror Side 1



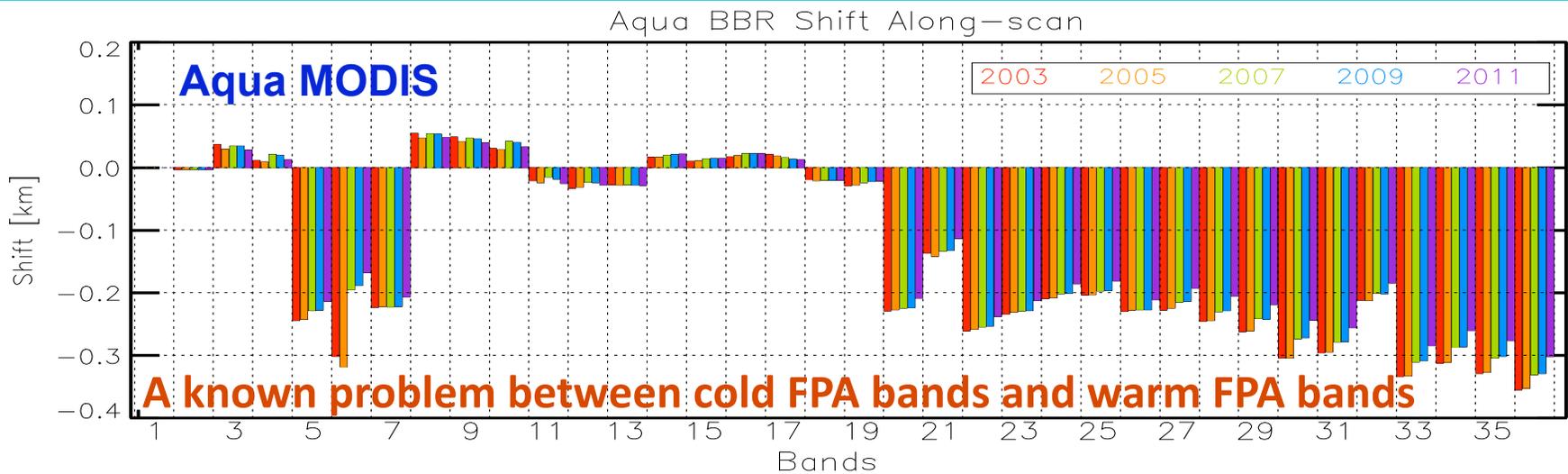
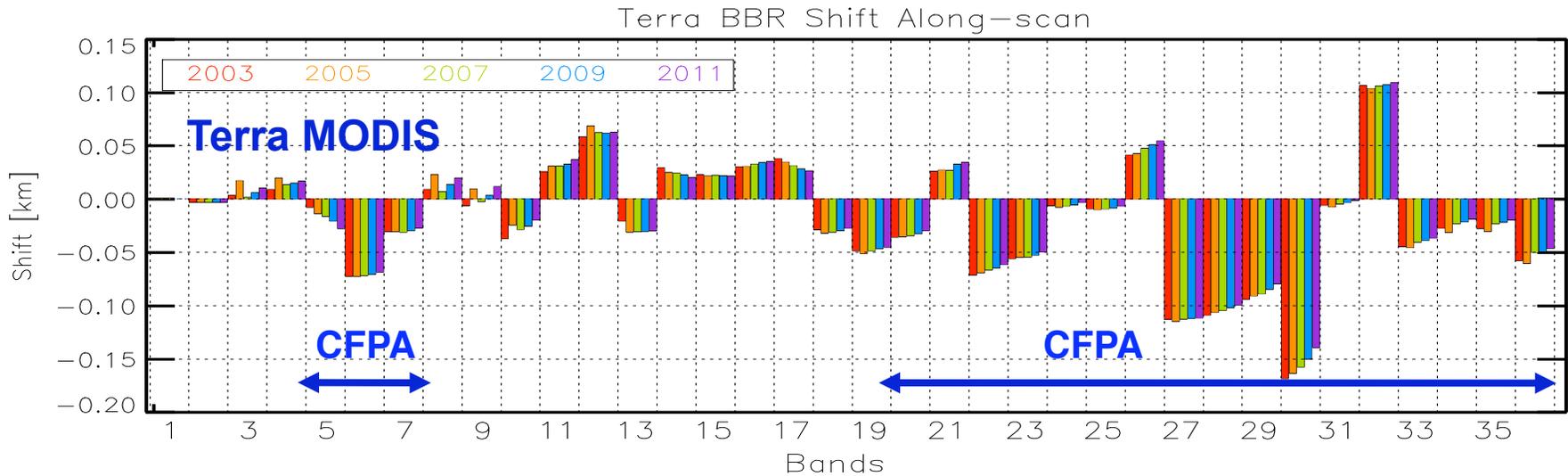
Relatively large gain changes (up to 7% over 11 years) for Terra LWIR PC bands *Page 13*

VIS and NIR Center Wavelengths (CW)



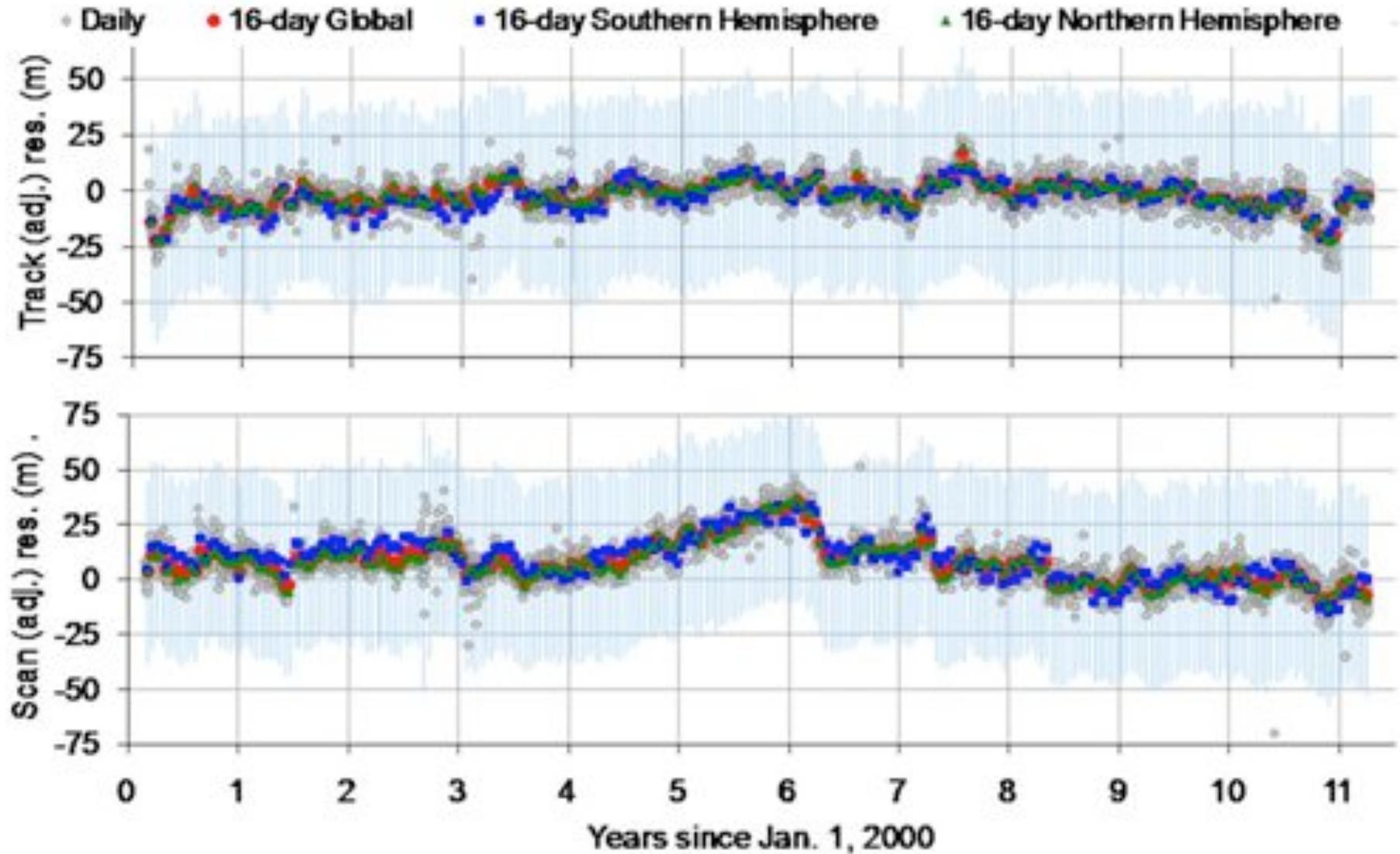
On-orbit changes in CW are less than 0.5 nm for most VIS/NIR

Band-to-Band Registration (BBR)

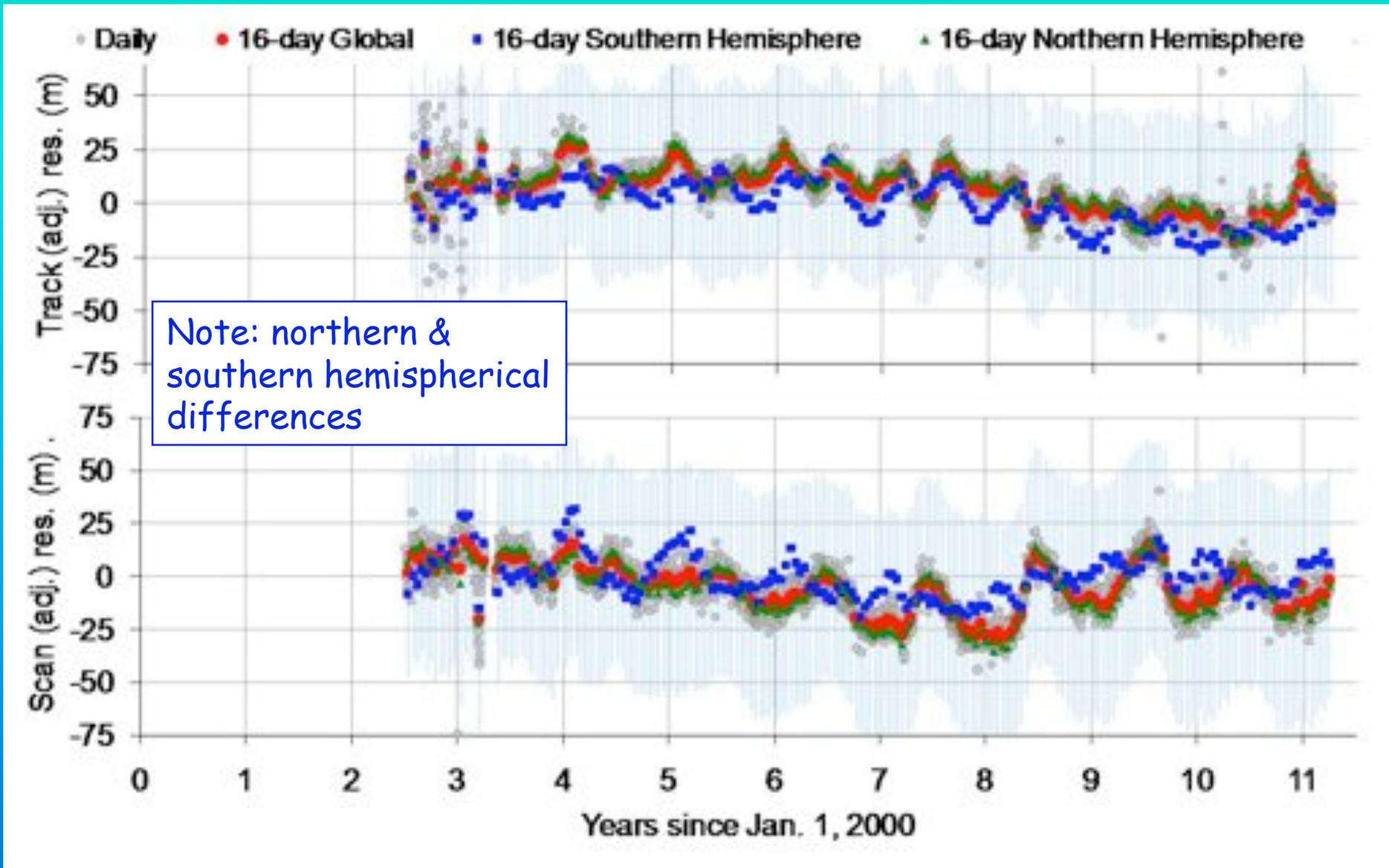


On-orbit changes in BBR are small in both scan and track directions

Terra MODIS Geolocation Results (C5)



Aqua MODIS Geolocation Results (C5)



Instrument Performance Summary (1)

- **Both instruments continue to operate normally**
 - Changes of instrument and warm FPA temperatures are less than 3.5K for Terra MODIS over 11 years; less than 2K for Aqua MODIS over 9 years
 - Terra MODIS cold FPA temperatures remain stably controlled at 83K
 - Gradual decrease of Aqua MODIS cooler margin has led to small increase (up to 0.30K), orbit-to-orbit and seasonal variations of its cold FPA temperatures
 - A workshop on Aqua MODIS CFPA performance and operation was held on May 7, 2010 (decision reached to maintain current operational configuration unless there is an evidence that the current CFPA performance has a negative impact on science data product quality)
- **All on-board calibrators continue to provide key design functions**
 - BB temperatures remain extremely stable for both Terra and Aqua MODIS, short- and long-term
 - Terra MODIS SD door has permanently fixed at the "open" position since July 2, 2003, which has led to increased SD degradation rates

Instrument Performance Summary (2)

- **Radiometric (36 spectral bands with 490 individual detectors)**
 - There are no new noisy and inoperable detectors since last STM
 - 45 noisy detectors (30 from pre-launch; 35 at launch) and no inoperable detectors for Terra MODIS
 - 6 noisy detectors (2 from pre-launch; 3 at launch) and 15 inoperable detectors (13 in band 6) for Aqua MODIS
- **Spectral (VIS/NIR bands only)**
 - Changes in center wavelengths and bandwidths are less than 0.5 and 1.0 nm, respectively, for most spectral bands (only a few exceptions)
- **Spatial (all bands)**
 - On-orbit band-to-band registrations (BBR) have been stable for both Terra and Aqua MODIS
 - Large BBR offsets in Aqua MODIS between cold FPA and warm FPA band pairs (a known problem since pre-launch)

Instrument Performance Summary (3)

- **Excellent geo-location accuracy and stability**
 - Terra MODIS RMS (C5): along-track 43m, along-scan 44m
 - C6 expected RMS: along-track 42m, along-scan 42m
 - Aqua MODIS RMS (C5): along-track 47m, along-scan 53m
 - C6 expected RMS: along-track 45m, along-scan 51m
 - Enhanced Terrain Correction (area-based) in C6
 - New DEM and land water mask in C6
- **Collection 5 processing status and collection 6 reprocessing plan**
 - Provided in the backup slides
- **DB of MODIS data products plays an important role**
 - Overall 150 stations

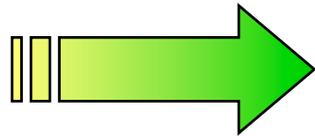
Challenges and Future Efforts

- Large changes in VIS spectral band/detector response
 - Mirror side, wavelength, and AOI dependent
 - Changes in sensor response versus scan-angle (RVS) and mirror polarization sensitivity
 - Noticeable impact for bands 8, 9, and 3, and likely other bands, more in Terra MODIS than Aqua MODIS
- Large SD degradation at short wavelengths, especially in Terra MODIS
 - Impact on the quality and accuracy of tracking SD degradation
- Aqua BBR impact on some products derived using bands from both warm and cold FPA (e.g. bands 2 and 7)
- TEB calibration quality over cold targets, mainly in Terra MODIS PV bands
- Calibration consistency between Terra and Aqua MODIS
 - ~~Scene dependent differences (offsets and trends)~~

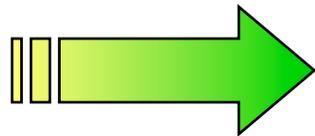
Improvements made via newly proposed collection 6 LUT

Some effects may still exist ...

EOS/MODIS to NPP/VIIRS, and beyond



Lessons
and
Experience



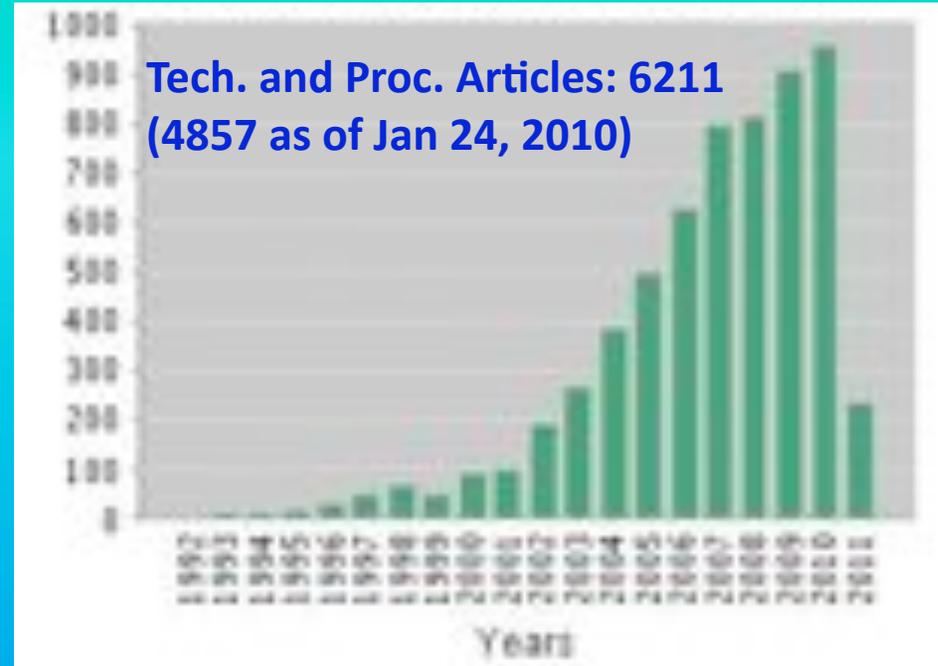
MODIS

VIIRS



NPP Spacecraft and
Instruments

MODIS Publication Metrics



Average citations: 13-14/per technical article

Google Scholar "HITS"

	May 7, 2008	Jan 24, 2010	May 11, 2011
NASA Terra:	19000	27100	34100
NASA Aqua:	8750	11800	16200
NASA MODIS:	14800	19500	30400

Collection 5 (C5) Processing Status

- Forward processing is typically 1-2 days behind real time
- NRT processing is typically 1.5 hours after observations
- Aqua and Terra deep blue reprocessing (C5.1) completed
- C5.1 Terra Cloud products were reprocessed after a processing flaw was found.
- The C4.1 LST (C4 code with C5 L1 input) is processed for the duration of C5
- C5/5.1 products will be generated through the completion of C6 reprocessing

Collection 6 (C6) Reprocessing Plan

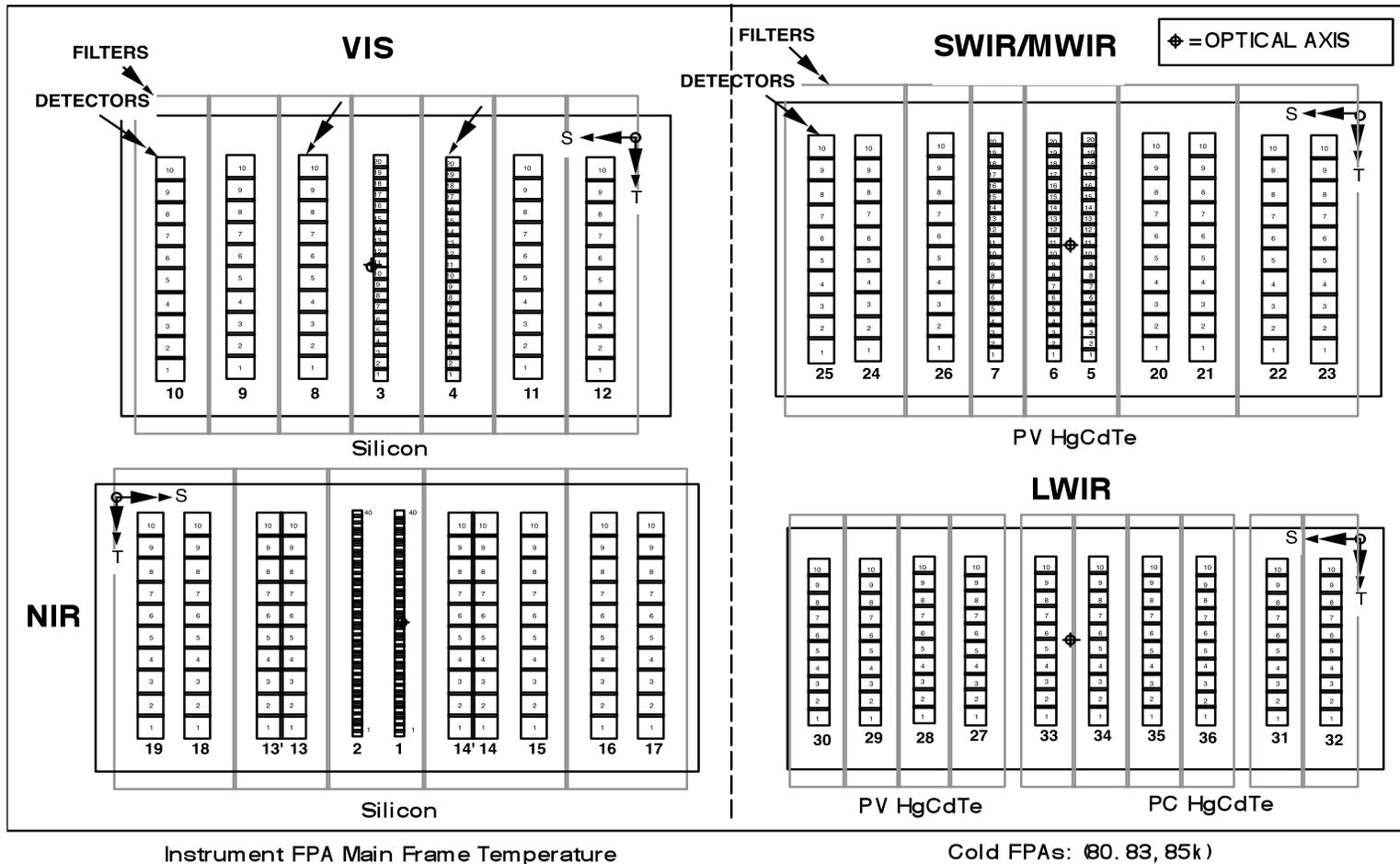
- C6 L1 and Cloud Mask/Profiles
 - Both PGE01 and PGE03 are ready for C6 reprocessing
 - Testing PGE02 with RSB and TEB Uncertainty updates, new RVS approach
 - Plan to start C6 L1 and Cloud Mask data reprocessing in the summer of 2011 and complete the reprocessing in 3 months.
- C6 Land and Atmospheres reprocessing
 - Atmospheres C6 reprocessing planned at 70x starting early 2012 to be completed by April, 2012.
 - Land C6 reprocessing will proceed at >30x and is expected to start in Summer 2012.
- LP and NSIDC DAACs will ingest land products into their archives at these production rates
- All C5/5.1 atmospheres and L1 products will be archived in LAADS until the next complete reprocessing (C6.x or C7)

MODIS Specifications and Applications

Primary Use	Band	Bandwidth (nm)	Spectral Radiance ¹	Required SNR	Primary Use	Band	Bandwidth (μm)	Spectral Radiance ¹	Required NEΔT(K)
Land/Cloud/Aerosols Boundaries	1	620 - 670	21.8	128	Surface/Cloud Temperature	20	3.660 - 3.840	0.45 (300K)	0.05
	2	841 - 876	24.7	201		21	3.929 - 3.989	2.38 (335K)	0.2
Land/Cloud/Aerosols Properties	3	459 - 479	35.3	243		22	3.929 - 3.989	0.67 (300K)	0.07
	4	545 - 565	29	228		23	4.020 - 4.080	0.79 (300K)	0.07
	5	1230 - 1250	5.4	74	Atmospheric Temperature	24	4.433 - 4.498	0.17 (250K)	0.25
	6	1628 - 1652	7.3	275		25	4.482 - 4.549	0.59 (275K)	0.25
	7	2105 - 2155	1	110	Cirrus Clouds Water Vapor	26	1.360 - 1.390	6	150 (SNR)
Ocean Color/ Phytoplankton/ Biogeochemistry	8	405 - 420	44.9	880		27	6.535 - 6.895	1.16 (240K)	0.25
	9	438 - 448	41.9	838		28	7.175 - 7.475	2.18 (250K)	0.25
	10	483 - 493	32.1	802		Cloud Properties	29	8.400 - 8.700	9.58 (300K)
	11	526 - 536	27.9	754	Ozone	30	9.580 - 9.880	3.69 (250K)	0.25
	12	546 - 556	21	750	Surface/Cloud Temperature	31	10.780 - 11.280	0.55 (300K)	0.05
	13	662 - 672	9.5	910		32	11.770 - 12.270	0.94 (300K)	0.05
	14	673 - 683	8.7	1087	Cloud Top Altitude	33	13.185 - 13.485	54.52 (260K)	0.25
	15	743 - 753	10.2	586		34	13.485 - 13.785	53.76 (250K)	0.25
16	862 - 877	6.2	516	35		13.785 - 14.085	53.11 (240K)	0.25	
Atmospheric Water Vapor	17	890 - 920	10	167		36	14.085 - 14.385	52.08 (220K)	0.35
	18	931 - 941	3.6	57	¹ Spectral Radiance values are (W/m ² μm-sr)				
	19	915 - 965	15	250					

- 20 reflective solar bands (RSB: bands 1-19, and 26) from 0.41 - 2.2μm
- 16 thermal emissive bands (TEB: bands 20-25, 27-36) from 3.5 - 14.4μm

MODIS Focal Plane Assemblies (FPA)

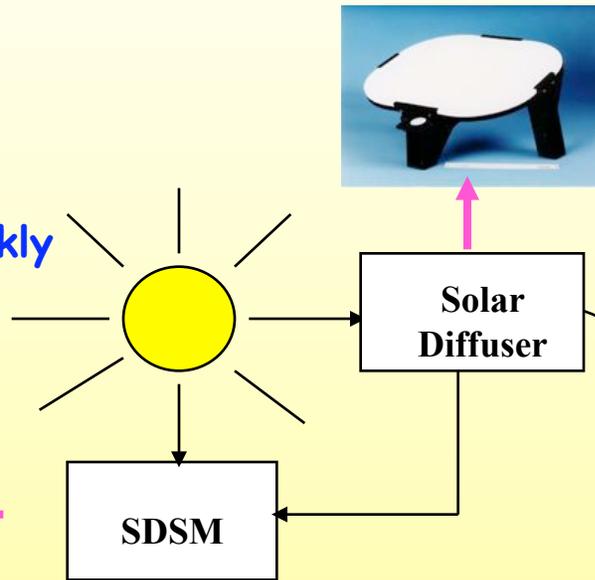


S: scan direction; T: track direction

B13 and B14 have 2 columns of detectors for TDI high and low gain output

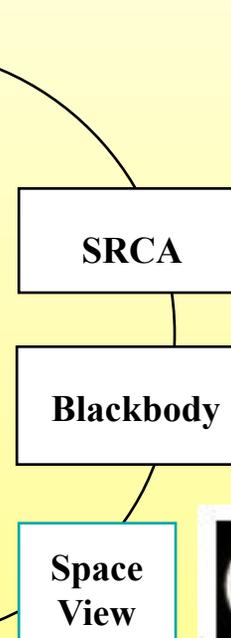
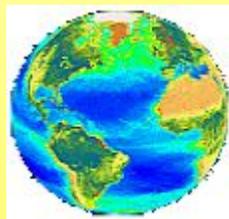
On-board Calibrator On-orbit Calibration

SD/SDSM:
Weekly to tri-weekly

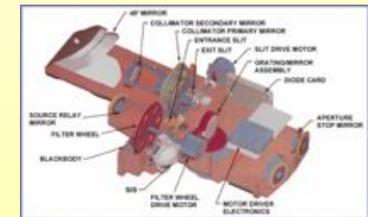


Scan
Mirror

Spacecraft maneuvers:
Yaw (SD BRF, VF)
Roll (Moon)
Pitch (only applied to Terra)



SRCA:
Radiometric: monthly
Spatial: bi-monthly
Spectral: quarterly



BB: quarterly

Moon: monthly (nighttime orbits)
0-20° spacecraft roll maneuvers
55° phase angle

